(19) Europäisches Pa   mt
European Patent Office
Offic   européen des br v ts

(11) Publication number: **0 035 462 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 81630010.7

(22) Date of filing: 30.01.81

(51) Int. Cl.³: **B 26 D 5/20** // B26D7/26

(30) Priority: 31.01.80 US 117200

(43) Date of publication of application: 09.09.81 Bulletin 81/36

(84) Designated Contracting States: AT DE FR IT SE

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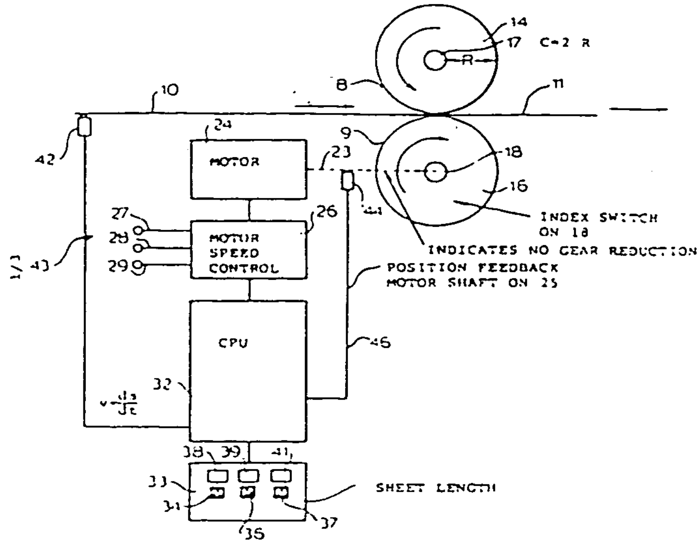
(54) **Cyclic electric drive for fine and coated paper cutter.**

(57) A paper cutting machine and method including a double rotary knife consisting of two cylinders geared together each containing a knife which mates with another to form a scissor action to cut a web including a sensor for detecting the speed of the web and including a motor for driving the two cylinders wherein the sheet size can be set to a desired size to provide an input to a microprocessor which is connected to the sheet speed sensor and to a position feedback from the drive motor and which generates a modulated signal for the motor so as to cause the knives to travel at the web speed at the instant of cutting and to modulate the cylinder speed to obtain larger or smaller sheets. Novel rotary drums and drive train system having low inertia are provided to allow the rapid acceleration necessary for the invention. Also, the knives are mounted in a novel manner.



EP 0 035 462 A2

CYCLIC ELECTRIC DRIVE FOR FINE AND COATED PAPER CUTTER

This invention relates in general to an electrical drive for cutting paper webbing.

For cuts of high quality, double rotary knife sections have been used which consist of two cylinders geared together each containing a knife which mates with another forming a scissor action to sever the web. In order to minimize dust, the knife tip velocity of the two knives must match the paper speed at the time the knives come into contact with the one another and the paper. For a single sheet size, the circumference of the knife path can be made equal to the sheet length and thus at constant speed the knife tip velocity will match the paper speed at the time of cut.

When there are a large number of different sizes to be cut, other means must be provided to assure that the knife speed is equal to the paper velocity at the time of cut. One prior art method is to provide different knife sections which are fitted onto the cylinders with the knives being changed for different sizes. Such system is quite expensive and time consuming to change the size of the sheets.

Another prior art method is to provide a mechanical linkage comprised of eccentrics that will accelerate or decelerate the knife tip to match the sheet speed at the time of cut. Such linkage is designated a drag link mechanism and the problems of inertia, wear, backlash and speed make such systems less accurate and very complicated.

The present invention utilizes a microprocessor which receives an input from a sheet speed sensor and an input from a position feedback detector which is connected to the output shaft of the drive motor for the cylindrical mounted knives and which includes a motor speed control which is controlled by the microprocessor to allow cuts of different sizes to be made. The speed sensor and position feedback devices may be pulse generators. In the present invention, cylinders having low inertia allows the motor control to vary the speed of the cylinders rapidly so as to make accurate cuts that can be maintained within plus and minus 0.015 tolerance.

The electrical drive system of the invention allows the operator to set the sheet length desired on a control which might include digital thumb switches. The sheet length is supplied to the microprocessor which chooses the computerized velocity and position curve which the knives must follow to cut the web after the required length of the material has passed. The microprocessor receives signals from the web speed sensor and position feedback from the output shaft of the motor and processes them with the input from the set sheet length by sending a signal to the motor speed regulator which in turn controls the motor. For a position of rotation, the motor supplies from the position feedback sensor a digital position signal to the microprocessor which then recalculates the position that the knife should be in at that particular instance. The computer continuously adjusts the speed of the motor so as to assure accurate control of the system.

Novel rotary drums of low inertia and having novel knife arrangements are also provided.

Other objects, features and advantages of the invention will be readily apparent from the following description of certain preferred embodiments thereof, taken in conjunction with the accompanying drawings although variations and modifications may be effected without departing from the spirit and scope of the novel concepts of the disclosure and in which:

Figure 1 is a schematic view illustrating the invention;

Figure 2 illustrates the cylinders and the motor driving them;

Figure 3 is a flow diagram for controlling the cylinders,

Figure 4 is a plot of the cylinder peripheral velocity verses time;

Figure 5 is a sectional view through the novel rotary drum of the invention; and

Figure 6 is a sectional view taken on line VI-VI of Figure 5.

The present invention allows accuracy in cutting

of sheets in the sheeting industry to within plus or minus 15 thousandths of an inch wherein the sheet speeds go up to 1200 feet per minute or higher.

Figure 1 illustrates the cutter of the invention comprising a web of sheet material 10 as, for example, paper which passes through a pair of cutter rolls 14 and 16 each of which carry cutter blades 8 and 9 so that they cooperate to shear the paper as it passes by the rollers 14 and 16. The cut sheets 11 are stacked in a pile 12 on a holder 13. The roller 14 is supported on a shaft 17 and the roller 16 is supported on the shaft 18. As best shown in Figure 2, the shafts 17 and 18 carry gears 19 and 21, respectively, and a gear 22 meshes with gear 21 to drive it. A motor 24 has an output shaft 23 which is connected to gear 22.

A suitable indexing means 25 which may be a photoelectric device is attached to motor 24. A position feedback sensor 44 is mounted on shaft 23 as illustrated in Figure 1 to provide an index to indicate the position of the cutters 8 and 9 relative to the sheet 10.

A microprocessor 32 receives on lead 46 the output of the position sensor 44. A digital sensor 42 which may be a pulse generator type is mounted adjacent the web 10 and detects the linear velocity of the paper web and supplies an output on lead 43 to the microprocessor 32 indicative of the velocity of the paper.

The microprocessor 32 also receives an input from a sheet length setting means 33 which has thumb knobs 34, 36 and 37 and indicators 38, 39 and 41 for setting the length of the sheets 12 to the desired dimension. In other words, the sheets 12 may be made shorter and longer by adjusting the knobs 34, 36 and 37. The output of the sheet length setting means 33 is supplied to the microprocessor 32.

In operation, the blades 8 and 9 must have the same peripheral velocity as the sheet 10 at a time when the blades 8 and 9 engage the paper. Thus, the velocity of the blades 8 and 9 must equal the velocity of the paper during the cutting interval. If the length

of the sheet is exactly equal to the circumference of the rollers 14 and 16, the rollers 14 and 16 can be run at a constant speed such that their peripheral speed is equal to the speed of the web 10. However, if it is desired that the sheet be longer than the circumference of the rollers 14 and 16, the knives 8 and 9 should travel at the peripheral speed which equals the speed of the web 10 during the instant of cutting but the rollers 14 and 16 should slow down between the cutting instances until the proper length of the sheets 12 has passed by the roller then the rollers 14 and 16 must be accelerated up to the web speed at the instant of cutting so the motion of the rollers 14 and 16 will be non-linear and will be as shown by curve 70 in Figure 4 which is a plot of velocity of the blades 8 and 9 relative to time. The portions of the curves 71 and 72 correspond to the instant of cutoff when the blades 8 and 9 engage the web 10 and the curve 70 indicates a velocity plot wherein the sheets are to be longer than the circumference of the rollers 14 and 16.

On the other hand, if the sheets 12 are to be shorter than the circumference of the rollers 14 and 16, it is desirable that the blades 8 and 9 travel at the same peripheral speed as the web speed at the instant of cutoff as indicated by curve portions 71 and 72, but the rollers 14 and 16 must then be accelerated to higher velocities between the cutoff intervals so that a shorter piece of the web 10 will pass by the rollers 14 and 16 between cutoff intervals. This is indicated by a curve 73 in Figure 4 and illustrates how the velocity of the rollers 14 and 16 must be modulated by the microprocessor 32 so as to obtain the proper length of sheets 12. Curve 74 illustrates the situation when the length of the sheet 12 is exactly equal to the circumference of the rollers 14 and 16 and wherein the velocity of the rollers does not vary.

The motor 24 receives an input from a motor speed control 26 which receives input power on leads 27, 28 and 29 as, for example, three phase AC power. The microprocessor 32 supplies an input to the motor speed control 26 for controlling the motor speed control which in turn adjusts

the rotary speed of the motor according to the desired sheet size set by the knobs 34,36 and 37.

Figure 3 comprises a flow diagram which explains the calculations made by the microprocessor 32. The sheet size is set as indicated by block 50 by adjusting the knobs 34, 36 and 37 to the desired sheet size.The sheet velocity is sensed as indicated by a block 51 and then the time between cutoffs is determined as indicated block 52. The position of the roller knives is sensed as indicated by a block 53 and the velocity of the rollers 14 and 16 is controlled by modulating the roller velocity by control of the motor 24 such that at cutoff the knives have the same peripheral velocity as the sheet as indicated by block 54. Block 56 indicates that the roller velocity is changed to correspond to the selected sheet size. Thus, with very simple programming the microprocessor 32 can provide sheets of great accuracy. The present invention is capable of cutoff lengths having accuracies of plus or minus 15 thousandths of an inch at speeds up to 1200 feet per minute.

An additional important aspect of the invention comprises the specially designed rotary drums which allows machine control with the invention to operate at much higher speeds than possible with apparatus of the prior art. The microprocessor which controls the electric drives optimizes acceleration and deceleration of the drums and the specially designed low inertia drums of the invention allows the acceleration and deceleration to be accomplished with reasonable amounts of power whereas the heavy drums used in prior art devices would make it impossible to obtain the accelerations and decelerations necessary for operation of the invention at the high speeds required.

Prior art drums were either cast drums or made of heavy wall steel tubes for rigidity.

Figures 5 and 6 illustrate the low inertia drums of the invention which are formed of cylindrical shels 80 and 120 for the upper drum 14 and the lower drum 16, respectively. The upper drum 14 is shown in greater detail in Figure 6 and in section and the general structures of both the upper and lower drums 14 and 16 are similar

and only the upper drum is shown in section for explanation. A pair of hub members 81 and 82 which are formed with inner hollow spaces so as to reduce the weight are respectively attached to the supporting shafts 17a and 17b which are supported in suitable bearings so that the upper and lower rolls 14 and 16 can be driven in synchronism. Attached to the hubs 81 and 82 are a pair of supporting members 83 and 91 which are formed in X-shape cross-section as illustrated in Figure 5 and have portions 84, 88, 86, 89 and 87 and 90 which extend to the inner surface of the outer cylindrical shell 80 of the drum and between these portions the material is removed so as to remove as much material and weight as possible and, thus, make the drum light so that it will have low inertia. The ends 84,88, 86, 89, 87 and 90 are attached as by welding to the shell 80 so that a rigid structure is provided. A counter-weight 101 is mounted and welded to the inner surface of the outer shell 80 as shown in Figure 5 and a tangential member 108 has opposite sides 106 and 107 connected to a truncated portion of the shell 80 and a knife 109 extends generally radially from the drum 80 and is carried on a bolt 111 that is threadedly received in the center portion 108 of the member 104 so as to allow the knife 109 to be adjustable to the left or right relative to Figure 5 which will cause the knife 109 to move radially relative to the drum since adjustment changes its position relative to the radius of the drum 80.

A second knife 97 is generally mounted tangentially with the bolt 98 to a member 96 mounted in the surface of drum 120 and is counter-balanced by a counter-weight 94 attached to the inside surface of the drum 120 as shown in Figure 5. Thus, the low weight drums 14 and 16 can be very rapidly accelerated and decelerated due to their low weight and inertia and the blades 109 and 97 can be adjusted for wear by using the adjustment means shown.

It is an important feature of the invention that a gear box has been eliminated. A pinion gear, coupled to the motor output shift is used to directly drive the connecting gears on the end of the cylinders. Prior art used a separate gear box with input at output shifts and

couplings. Our system further reduces inertia by such elimination of the prior art separate gear box.

Although the invention has been described with respect to preferred embodiments, it is not to be so limited as changes and modifications may be made which are within the full intended scope as defined by the appended claims.

Claims:

1. Apparatus for cutting a moving web into sheets characterized in that it comprises at least one knife supported for rotary motion on one side of the sheet and periodically engageable with the web to cut it, motor means for driving said knife, a velocity sensing means mounted to detect the velocity of the web, a position feedback means mounted to detect the rotary position of said knife, setting means for setting the desired length of the sheets, a computer means receiving inputs from said setting means, said position feedback means, and said velocity sensing means and producing a control signal which is supplied to said motor means such that the velocity of said knife is equal to the velocity of said web at the instant of cutoff and the rotary velocity of said knife between the instances of cutoff is such that the sheets have the set sizes.

2. Apparatus according to claim 1 characterized by two rotary knives mounted on opposite sides of said web and said motor means drives both of said knives.

3. Apparatus according to claim 2, characterized in that said knives are respectively mounted on a pair of drums on opposite sides of said web and said motor means drives said drums.

4. Apparatus according to claim 3, characterized in that it includes a motor speed control connected between said motor and said computer means.

5. Apparatus according to claim 3, characterized in that said pair of drums each comprise hollow cylindrical shells with a pair of hub members attached to the ends of said shells with stub shafts attached to said hub members for rotary supporting said drums.

6. Apparatus according to claim 5, characterized in that each of said drums include X-shaped brace members mounted within said hollow cylindrical shells and attached at their opposite ends to said hub members.

7. Apparatus according to claim 6, characterized in that one of said drums has a portion of said shell removed and a tangential knife supporting structure is mounted in

said shell where the portion is removed, and a first knife which extends generally tangentially is mounted to said tangential knife supporting structure.

8. Apparatus according to claim 7, characterized in that the other of said drums has a portion of said shell removed and a radial knife supporting structure is mounted in said shell where the portion is removed, and a second knife which extends generally radially is mounted to said radial knife supporting structure.

9. Apparatus according to claim 8, characterized in that the position of said second knife is adjustable radially relative to said second drum.

10. The method of cutting a moving web into sheets with a motor driven rotary knife, characterized in that it comprises the steps of detecting the velocity of said web, detecting the rotary position of said knife, setting the desired sheet length, calculating a motor drive signal from the velocity of said web, the position of said knife, and the set sheet length, and supplying said motor drive signal to said motor to drive said knife.

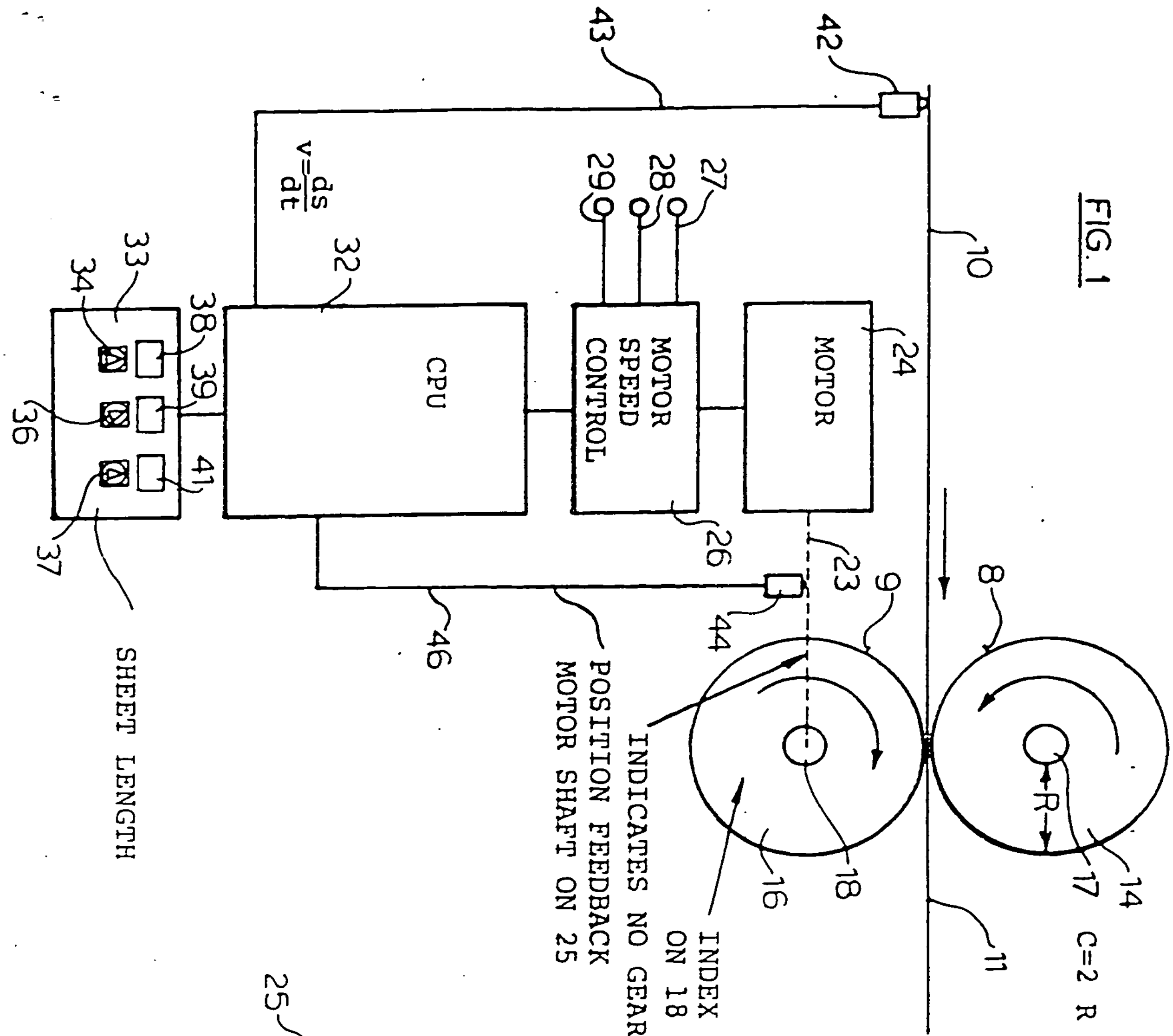

MOTOR
MOTOR SPEED CONTROL
CPU
$v=\frac{ds}{dt}$
C=2 R
R
INDEX SWITCH ON 18
INDICATES NO GEAR REDUCTION
POSITION FEEDBACK MOTOR SHAFT ON 25
SHEET LENGTH

FIG. 1

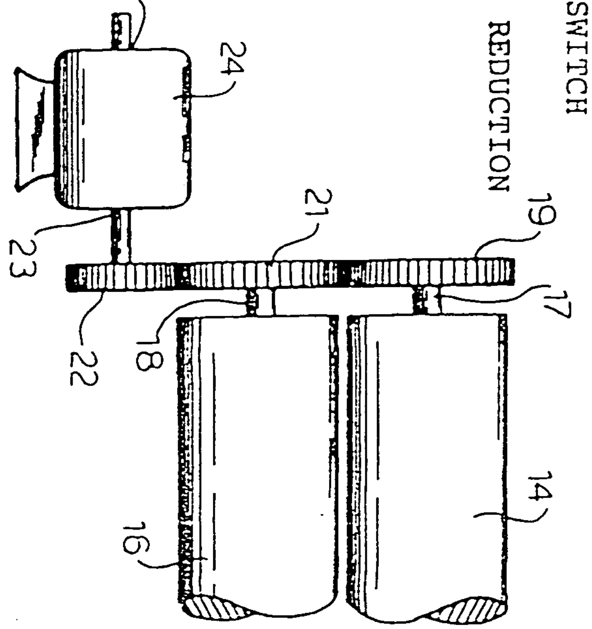


FIG. 2

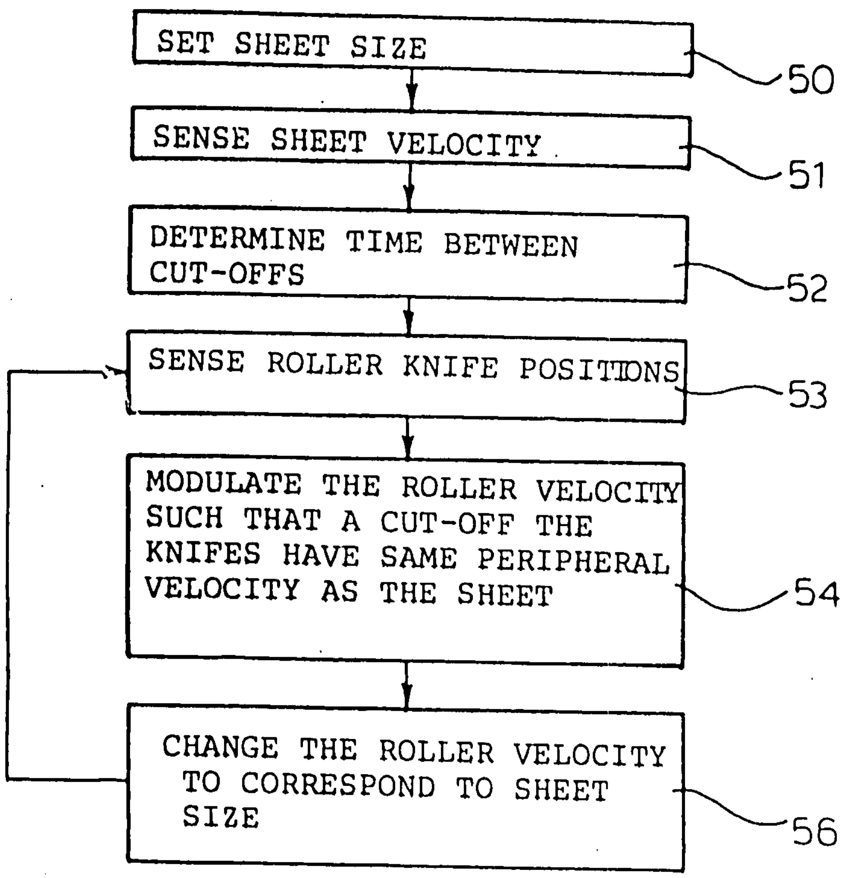

SET SHEET SIZE
50
SENSE SHEET VELOCITY
51
DETERMINE TIME BETWEEN CUT-OFFS
52
SENSE ROLLER KNIFE POSITIONS
53
MODULATE THE ROLLER VELOCITY SUCH THAT A CUT-OFF THE KNIFES HAVE SAME PERIPHERAL VELOCITY AS THE SHEET
54
CHANGE THE ROLLER VELOCITY TO CORRESPOND TO SHEET SIZE
56

FIG. 3

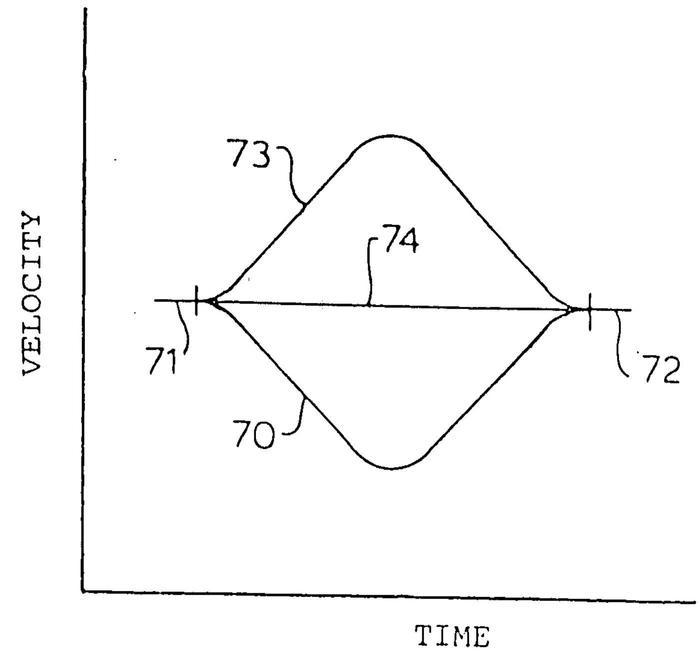
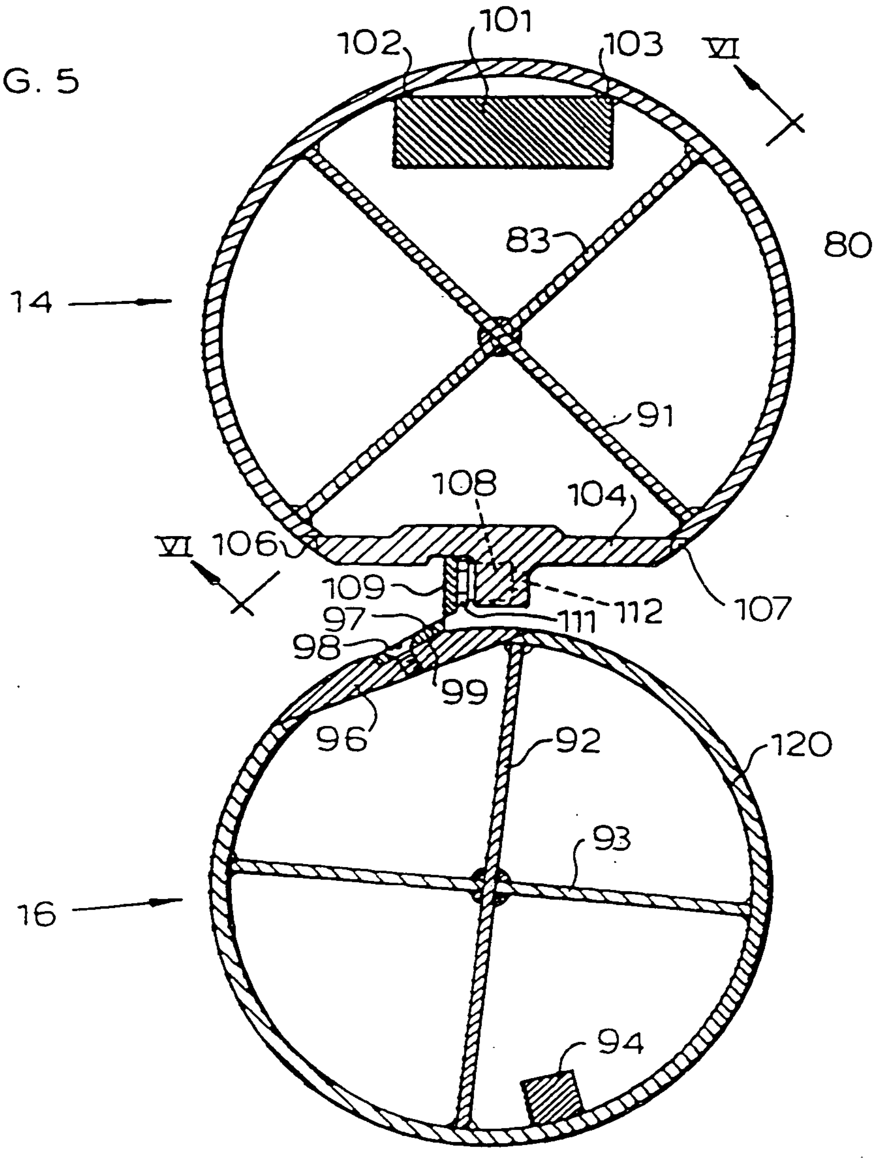

VELOCITY
TIME
73
74
71
72
70

FIG. 4

FIG. 5


101
102
103
VI
83
80
14
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VI
106
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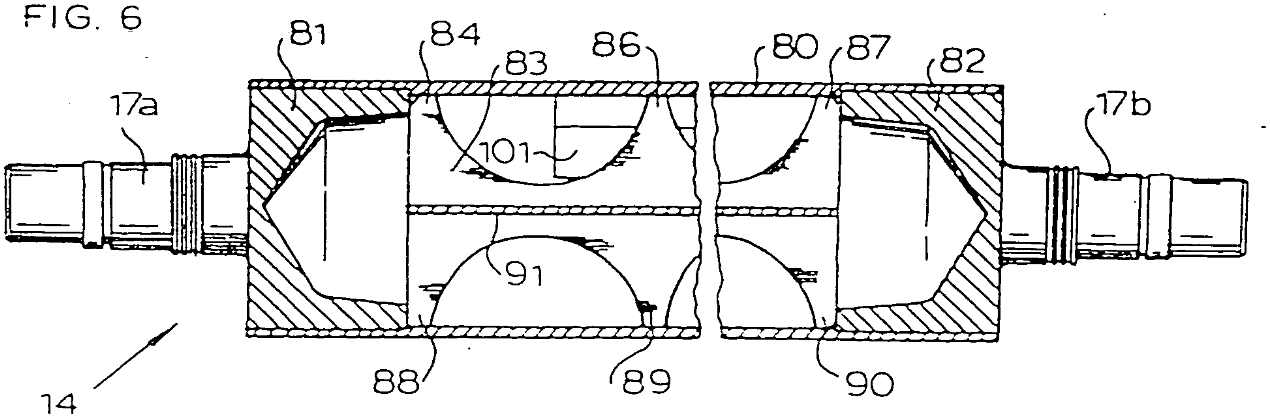
112
107
97
111
98
99
96
92
120
93
16
94

FIG. 6


81
84
83
86
80
87
82
17a
101
17b
91
14
88
89
90